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Description

MULTIPOLE, PERMANENT-MAGNET ROTOR FOR A ROTATING  
ELECTRICAL MACHINE, AND A METHOD FOR PRODUCING SUCH A  
ROTOR SAME

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CLAIM FOR PRIORITY

This application claims priority to International  
Application No. PCT/DE00/00853 which published in the  
German language on September 28, 2000.

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TECHNICAL FIELD OF THE INVENTION

The invention relates to the field of rotating electrical  
machines, and ~~is applicable~~ in particular, to the design  
configuration of rotor cores which are fitted with  
15 permanent magnets using ~~what is referred to as~~ a flux  
concentration construction.

BACKGROUND OF THE INVENTION

Special ~~Now that special permanent magnets, referred to as  
hard ferrite, have been successfully developed~~ i.e., which  
20 are matched to the stringent requirements of electrical  
machines, ~~such magnets have now been used to an ever  
greater extent~~ have been successfully developed. Such  
magnets are used to produce the rotating magnetic field in  
the rotating electrical machines. Various options for the  
25 arrangement of the permanent magnets in the rotor or in  
the stator have been developed for motors and generators  
with rated powers up to 30 kW at 3000 rpm. In this case,  
~~what is referred to as~~ the "flux concentration  
construction" has been found to be the technically better  
30 solution above a rated power of several hundred watts. One  
embodiment of this construction is to arrange the  
permanent magnets in the pole gaps in the rotor (Siemens  
Journal 49, 1975, Issue 6, page 368 et seq./369, Figure  
3). One known design solution for this purpose is to

arrange the permanent magnets, which have a flat rectangular cross section and are designed to be flat in the magnetization direction, radially with respect to the rotor axis in slot-like spaces in each case between two  
5 yokes that are fixed on the rotor body (EP 0 582 721 B1).

~~In another known rotor~~ Rotors, fitted with permanent magnets, for an electrical machine, and having poles which are welded to a hollow rotor shaft are shaped in such a manner that there is an accommodation area with a  
10 trapezoidal cross section between two poles, for permanent magnets which likewise have a trapezoidal cross section. The outer surface of the rotor is, in this case, formed by shrunk-on reinforcements composed of a copper-beryllium alloy (US 4,242,610).

15 ~~With regard to the handling~~ To handle of permanent magnets when constructing rotors of electrical machines, ~~it is furthermore known for the magnet bodies to be~~ are installed in the unmagnetized state and ~~to be~~ are magnetized once they have been arranged on the rotor, for  
20 example using the stator winding of the electrical machine (EP 0 195 741 B1).

~~Such magnets~~ Magnets which store a large amount of energy, for example based on neodymium-iron-boron (NeFeB), have been developed recently, ~~the~~. The use of permanent-magnet  
25 rotors is now feasible even for electrical machines with a rated power of more than 100 kW, for example in ship propulsion systems with a rated power of 5 to 30 W. Machines such as these have a rotor diameter of more than 25 cm up to about 300 cm. If the rotors of machines such  
30 as these are constructed using flux concentration, this involves difficulties in the installation and securing of

the magnets.

Against the background of a permanent magnet rotor having the features in the precharacterized clause of patent claim 1, the invention is based on the object of designing the rotor construction such that the permanent magnets can be stored without exerting large amounts of force. In order to achieve this object, the invention provides for each yoke to be subdivided in the circumferential direction into two half-yokes, which each extend over half of one pole pitch, and that the two mutually adjacent half-yokes of two yokes arranged alongside one another are in each case connected by means of end points to form a pole element, and each pole element is fixed on its own on the rotor body. In this case, the pole elements can be designed such that either each of the two half-yokes is fitted with permanent magnets on its surface facing a slot-like intermediate space, or such that only one of the two half-yokes is fitted with permanent magnets on the surface facing the other half yoke. If the permanent magnets are arranged on the corresponding surfaces of the half-yokes and of the pole elements on the rotor body, it is expedient for the magnets to be fitted to the half-yokes in the unmagnetized state, and for the magnets to be magnetized once the two half-yokes have been joined together to form a pole element, but before the pole elements are fitted onto the rotor body.

Such a configuration of the poles and association between the magnets and the poles of the rotor allows both the pole elements, which comprise the half-yokes and magnets, and the individual magnets to be handled without exerting any excessive force while being arranged generally by bonding on the corresponding surfaces of the half-yokes.

In the case of relatively long rotors, it is also recommended that the individual pole elements be subdivided into a number of partial pole elements in the axial direction of the rotor, in order to produce  
5 convenient units which are easy to magnetize.

When the individual parts of a pole element are being joined together, it may be expedient to fill the spaces which remain between the two half yokes with a material  
10 which expands under the influence of impregnation resins. Furthermore, the permanent magnets which are arranged between the half yokes can also be secured in the radial direction by double wedges, which are supported on corresponding projections on the half yokes.

15 The two half yokes which form a pole element are in each case expediently connected by means of two preferably amagnetic end plates, which are screwed and pinned to the two half yokes and permanently fix the two half yokes with  
20 respect to one another. Once the pole elements have been assembled, they can be provided with surface protection by subsequent impregnation with a resin which, in particular, protects the corrosion sensitive permanent magnets permanently against damaging influences.

25 Once the pole has been magnetized, they are placed on the tubular rotor body, and are screwed to it from the inside or outside. The rotor body is in this case preferably amagnetic.

30 The configuration of permanent magnet rotors provided according to the invention can be applied both to machines with an internal rotor and to machines with an external rotor. External rotor machines may be, in particular,

~~generators in wind power systems, or drive motors for hoist systems.~~

#### SUMMARY OF THE INVENTION

5        In one embodiment of the invention, there is a  
multipole, permanent-magnet rotor for a rotating  
electrical machine. The rotor includes, for example,  
permanent magnets to produce salient magnet poles and  
designed to be flat in a magnetization direction arranged  
10   radially with respect to a rotor axis in slot-like spaces  
between two yokes fixed on a rotor body, wherein each yoke  
is subdivided in a circumferential direction into two  
mutually adjacent half-yokes which extend over half of one  
pole pitch, and the two half-yokes of the two yokes are  
15   arranged alongside one another and are connected by end  
points to form a pole element, the pole element fixed on  
the rotor body.

In another aspect of the invention, each of the two  
half-yokes is fitted with permanent magnets on a surface  
20   facing a slot-like intermediate space.

In another aspect of the invention, the intermediate  
space which remains between the two half-yokes of the pole  
elements is filled with material which is configured to  
expand under the influence of impregnation resin.

25        In yet another aspect of the invention, the permanent  
magnets are secured radially by double wedges.

In another aspect of the invention, the pole element  
is subdivided into a number of partial pole elements in an  
axial direction of the rotor.

30        In another embodiment of the invention, there is a  
method for producing a permanent-magnet rotor. The method  
includes, for example, magnetizing non-magnetical magnets

before being arranged on a rotor body, and arranging radially permanent magnets to produce salient magnet poles which are configured to be flat in a magnetization direction with respect to a rotor axis in slot-like spaces between two yokes fixed on the rotor body, wherein each yoke is subdivided in a circumferential direction into two mutually adjacent half-yokes which extend over half of one pole pitch, the two half-yokes of the two yokes are arranged alongside one another and are connected by end points to form a pole element, the pole element fixed on the rotor body, and the magnets are magnetized once the two half-yokes have been joined together to form a pole element.

In still another aspect of the invention, the permanent magnets are cuboid.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Three exemplary embodiments of rotors designed and produced according to the invention are illustrated, in detail form, in ~~Figures 1 to 5,~~ in which:

Figure 1 shows a ~~first~~ an exemplary embodiment of the configuration of the poles and yokes of the present invention.

Figure 2 shows a front view of a pole element designed according to the invention,

Figure 3 shows the subdivision of a pole element into a number of partial pole elements,

Figure 4 shows a ~~second~~ an exemplary embodiment of the configuration of poles and yokes, and

Figure 5 shows the configuration of poles and yokes

arranged on an external rotor.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

5    The invention discloses a rotor construction such that the permanent magnet can be stored without exerting large amounts of force.

10    This is achieved by providing for each yoke to be subdivided in the circumferential direction into two half yokes, each of which extend over half of one pole pitch. Two mutually adjacent half-yokes of two yokes are arranged  
15    alongside one another and are in each case connected by means of end points to form a pole element. Each pole element is fixed on its own on the rotor body. In this case, the pole elements can be designed such that either each of the two half-yokes is fitted with permanent  
20    magnets on its surface facing a slot-like intermediate space, or such that only one of the two half-yokes is fitted with permanent magnets on the surface facing the other half-yoke. If the permanent magnets are arranged on the corresponding surfaces of the half-yokes and of the  
25    pole elements on the rotor body, it is expedient for the magnets to be fitted to the half-yokes in the unmagnetized state, and for the magnets to be magnetized once the two half-yokes have been joined together to form a pole element, but before the pole elements are fitted onto the rotor body.

30    Such a configuration of the poles and association between the magnets and the poles of the rotor allows both the pole elements, which comprise the half-yokes and magnets, and the individual magnets to be handled without exerting any excessive force while being arranged - generally by

bonding - on the corresponding surfaces of the half-yokes.  
In the case of relatively long rotors, it is also  
preferable that the individual pole elements be subdivided  
into a number of partial pole elements in the axial  
5 direction of the rotor, in order to produce convenient  
units which are easy to magnetize.

When the individual parts of a pole element are being  
joined together, it may be expedient to fill the spaces  
which remain between the two half-yokes with a material  
10 which expands under the influence of impregnation resins.  
Furthermore, the permanent magnets which are arranged  
between the half-yokes can also be secured in the radial  
direction by double wedges, which are supported on  
corresponding projections on the half-yokes.

15 The two half-yokes which form a pole element are in each  
case connected by two preferably a magnetic end plates,  
which are screwed and pinned to the two half-yokes and  
permanently fix the two half-yokes with respect to one  
another. Once the pole elements have been assembled, they  
20 can be provided with surface protection by subsequent  
impregnation with a resin which, in particular, protects  
the corrosion-sensitive permanent magnets permanently  
against damaging influences.

Once the pole has been magnetized, they are placed on the  
25 tubular rotor body, and are screwed to it from the inside  
or outside. The rotor body is in this case preferably a  
magnetic.

The configuration of permanent-magnet rotors provided  
according to the invention can be applied both to machines



with an internal rotor and to machines with an external rotor. External rotor machines may be, in particular, generators in wind power systems, or drive motors for hoist systems.

5 Figure 1 shows ~~Figure 1 shows, in the form of a detail,~~ a cross-sectional region of a rotor of an electrical machine, which comprises a rotor body 1, rotor yokes 2/3 mounted on the rotor body 1, and permanent magnets 5 mounted on the rotor yokes. Each rotor yoke is ~~in this~~  
10 ease subdivided into two half-yokes 2, 3, with a slot-like intermediate space 4 being provided between each two yokes. The permanent magnets 5 are magnetized in the circumferential direction and are arranged in the slot-like intermediate spaces 4, with one permanent magnet 5,  
15 or one magnet layer comprising a large number of relatively small permanent magnets, in each case being arranged on that surface of the respective half-yoke which faces the slot-like intermediate space 4. The permanent magnets 5 are in this case normally bonded to the half-  
20 yoke 2 or 3. Alternatively, the two magnet layers can also be associated with only one of the two half-yokes.

The space which remains between two half-yokes 3 and 2 and between the mutually adjacent permanent magnets 5 may be filled, ~~if required,~~ in one embodiment, with a material  
25 9 which can expand under the influence of impregnation resin. Furthermore, to provide radial fixing for the permanent magnets 5, double wedges 8 can be arranged both between the rotor body 1 and the permanent magnets, and between the permanent magnets and the periphery of the  
30 rotor.

According to Figure 2, two half-yokes 3, 2 are associated

with different yokes are in each case joined to the permanent magnets 5 arranged on the corresponding side surfaces, by ~~means of~~ end plates 6, to form a pole element 7. A number of such pole elements are arranged independently of one another on the circumference of the rotor body 1, and are connected to the rotor body, for example by ~~means of~~ a screw joint.

During the production of the pole elements 7, it is ~~expedient firstly~~ preferable to arrange, for example to bond, the permanent magnet (which has not yet been magnetized) on the corresponding side surface of the half-yoke 2 or 3. Two half-yokes 2, 3 are then associated with one another, and are fixed with respect to one another by ~~means of~~ two end plates 6. After this, the pole element 7 that has been produced in this way is inserted into a magnetization apparatus, and the permanent magnets 5 are magnetized. The magnetized pole element 7 can then be arranged on the rotor body 1.

In electrical machines having a relatively long rotor, it is ~~recommended~~ preferable that the respective pole element 7 be subdivided into partial pole elements 73 in the axial direction of the rotor, as is illustrated in Figure 3. In this case, a number of partial pole elements as illustrated in Figure 2 are then arranged axially one behind the other on the rotor body.

Figure 4 shows a ~~variant~~ an alternative embodiment of Figure 1. In this case, the half-yokes 2', 3' are assigned such that there is a cavity 71, which acts as a flux barrier, between them. The proportion of the magnetic flux produced in the individual half-yokes by the stator winding can then be influenced via this cavity.

The rotor illustrated in Figure 5 is an external rotor with an externally arranged supporting body 11. The arrangement of half-yokes 2'' and 3'' and the configuration of the permanent magnets 5 corresponds in principle to the exemplary embodiments shown in Figures 1 and 4. In this case, in contrast to Figure 4, a V-shaped, flux-free area 72 is provided between each two half-yokes.